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(54) **Improved LED efficiency using photonic crystal structure**

(57) A photonic crystal light emitting diode ("PX-LED") is provided. The PXLED includes a periodic structure, such as a lattice of holes, formed in the semiconductor layers of an LED. The parameters of the periodic structure are such that the energy of the photons, emitted by the PXLED, lies close to a band edge of the band structure of the periodic structure. Metal electrode layers have a strong influence on the efficiency of the PX-LEDs. Also, PXLEDs formed from GaN have a low surface recombination velocity and hence a high efficiency.

The PXLEDs are formed with novel fabrication techniques, such as the epitaxial lateral overgrowth technique over a patterned masking layer, yielding semiconductor layers with low defect density. Inverting the PX-LED to expose the pattern of the masking layer or using the Talbot effect to create an aligned second patterned masking layer allows the formation of PXLEDs with low defect density.

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EUROPEAN SEARCH REPORT

Application Number  
EP 03 07 6017

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 1 April 2005	Examiner Kästner, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

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EUROPEAN SEARCH REPORT

Application Number  
EP 03 07 6017

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15	Place of search <b>The Hague</b>	Date of completion of the search <b>1 April 2005</b>	Examiner <b>Kästner, M</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	

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European Patent  
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EUROPEAN SEARCH REPORT

Application Number  
EP 03 07 6017

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
15 The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 1 April 2005	Examiner Kästner, M
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EPO FORM 1503 03.82 (P04/C01)

**CLAIMS INCURRING FEES**

The present European patent application comprised at the time of filing more than ten claims.

- Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

**LACK OF UNITY OF INVENTION**

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-56

see below

1.1. claims: 1-24

an LED comprising: a semiconductor layer which has a periodically varying thickness and electrode layers

1.2. claims: 25-46

an LED comprising a semiconductor layer which has a periodically varying thickness

1.3. claims: 47-56

a method of making an LED, said method comprising a step of providing a photosensitive layer on top of an electrode layer, said photosensitive layer having a lattice of holes  
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2. claims: 57-74

a method of making an LED, comprising a step of providing a masking layer on top of a substrate, said masking layer having a lattice of holes.  
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3. claims: 75-92

a method of making an LED, comprising a step of  
 - providing a masking layer on top of a substrate, said masking layer having a lattice of openings, and  
 - providing semiconductor layers on on said masking layer, and  
 - providing a photosensitive layer on said semiconductor layers, and  
 - a step of exposing the photosensitive layer to light from the direction of said substrate.  
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Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 07 6017

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

01-04-2005

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